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Computational Fluid Dynamic Analysis of Delta Wing at Low Mach Number

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ABSTRACT: *The apprehension and the visualization of the aerodynamic characteristics of the fluid stream passage over the wing of an aircraft at different Mach number and various angles of attack is an important task in the pre design requirement and the safe and efficient operational envelope of an aircraft. The fighter aircrafts are special kind of aircrafts due to their maneuverability. During the maneuvering operation the aircraft wings works at a different angle of attacks and variations in the mach of free stream velocity over the aircraft wing due to the angle of attack variations which results in flow separation over the wing which in turn results in the aerodynamic forces variation over the wing. CFD analysis provides an efficient approach to visualize the flow and determining the aerodynamic forces characteristics over the aircraft. This analysis is applied for the pressure distribution, shear strength, free stream velocities, kinetic energy and their variations over the wing at various subsonic Mach number flows and angle of attack variations. This project investigates the aerodynamic flow properties and variations over flat delta shaped half wing with sharp leading edge with a rearward sweep of 60 ^{0} under varying free stream Mach number under subsonic range (0.2, 0.4 and 0.6) and varying angle of attacks(10,15 and 20 degrees).*

KEYWORDS - *Mach number, Angle of attack, Operational envelope, Maneuverability, Free stream velocity, CFD analysis, Rear ward sweep*

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I. INTRODUCTION

The aerodynamic characteristics of the wing, the wing has the effect of leading-edge sweeping the vortex lift is generated, which causes the airflow to separate, thereby allowing the wing to generate more lift. In spite of, if the wing has a sufficient sweep angle, an aircraft with a relatively small wing thickness can reduce wave resistance, so the leading edge of the wing does not come in to the contact with the shock wave formed on the nose bridge of the fuselage. Paired with the rear position of the rear edge of the delta wing will result in a higher pitching moment. The large surface area of the wing may reduce the speed of the wing for aircraft, it can keep the pitch angle of the delta wing stable because it can have a larger stall angle of attack. But because the surface area of the wing is so large, it will have greater viscous resistance for the same wing. The L/D ratio is low, so the lift is large. In order to compensate for the poor low-speed aircraft, the angle of attack must be increased at low speeds to obtain elevator Due to the larger sweep angle of the delta wing, during high angles of attack, the leading edge the vortex system will form around the delta wing. Achieve basic learning the aerodynamic characteristics and its influence on the wing aerodynamics were analyzed by CFD use ANSYS.CFD simulation to analyze based on various design parameters to analyze the flow variables from the inlet to the outlet through the ultrasonic nozzle. Wedge CFD Simulation Research on Different Wedge Angles and Mach Numbers. LEV originally came from the lower surface of the wing. split into two the flow lines below include inner flow and outer flow. Inboard current will travel the downstream velocity component moves downstream. Although the external stream is one person went out and tried to curl on the leading edge, reaching the top surface of Gortdz. With a sharp leading edge, the flow separates along the leading edge a strong shear layer is formed, which spirals upwards, causing large vortices to form LEVs. When the airflow bypasses the primary vortices and flows back to the leading edge, An unfavorable pressure can cause the reconnected flow to separate, forming a secondary flow counter-rotating vortex (the vortex can also have a three-stage structure). This formation of secondary vortices (most noticeable at high aoa) will move the primary vortices in and upwards on the surface of the wing. This change is bigger If the boundary layer on the top surface is laminar, because the flow separates earlier and forms larger secondary vortex. The Reynolds number has less effect on the vortex structure on the sharp leading edge delta wing. For sharp wings with high angles of incidence (Has a completely developed leading edge vortex), the flow pattern depends on Re.This LEV will cause the velocity near to the upper wall of the wing to increase, therefore, as the speed increases, a high suction peak will be produced and the pressure will decreases and absorb more airflow. The pressure on the water surface under the wing will rise and cause the increase in lift and stall of the wing was also delayed.The position of the surface suction peak indicates the position of the main front swirl. This leads to an increase in lift, commonly referred to as nonlinear lift or vortex lift.

II. METHODOLOGY

Theoretical approach:

The Navier-Stokes equation constitutes the most general flow formula, and the fluid continuity assumption can be assumed for this formula. The Navier-Stokes equation, for an ideal gas, does not generate heat, and the field force can be ignored. Two other assumptions are adopted: there is no heat transfer, that is, the heat flux vector term is equal to zero, and because the Mach number considered here is low, the flow is considered incompressible. In addition, since turbulence effects may be important in the current situation, the Reynolds average Navier-Stokes equation is used for flow analysis.The equations contain certain variables which depicts the effect of turbulent flow which must be solved using shear transfer model for turbulence closure.

Numerical approach:

The current calculations thought about unstructured networks, and they are created utilizing the CFD code as of now accessible. The arrangements of the fierce progressions of interest depend on the Reynolds Average Navier Stoke (RANS) conditions, upheld by SST disturbance analysis. In this current case study, the CFD utilizes density constant flow. This analysis utilizes a cell centered vertex, limited component referred on control volume strategy.

Grid Generation:

The region of interest where solution is required is known as domain of computation. Extent of domain is very crucial as it required for the accuracy of the solution and computational time. In this analysis we used an unstructured grid. In the unstructured grid the elements or control volume can have any shape. Grids may be orthogonal or non-orthogonal in shape. The unstructured grid is very well suited for structures having complex geometry. It has irregularity in data structure and difficulty in node connectivity.

III. DESIGN

In this analysis the configuration of test subject used is a sharp edged delta shaped half wing with backward sweep of 60 degree and the chord length of 10meters and span length is 5meters.

Boundary Conditions :

The right use of limit parameters is indispensable to appropriately sort the mathematical issue, guaranteeing right displaying. The INLET parameter is applicable through the computational space surface entry. In this limit, the free stream scalars and its heading are indicated.

The NO-SLIP WALL limit parameter is utilized over the airplane surface, as regular for a gooey reenactment

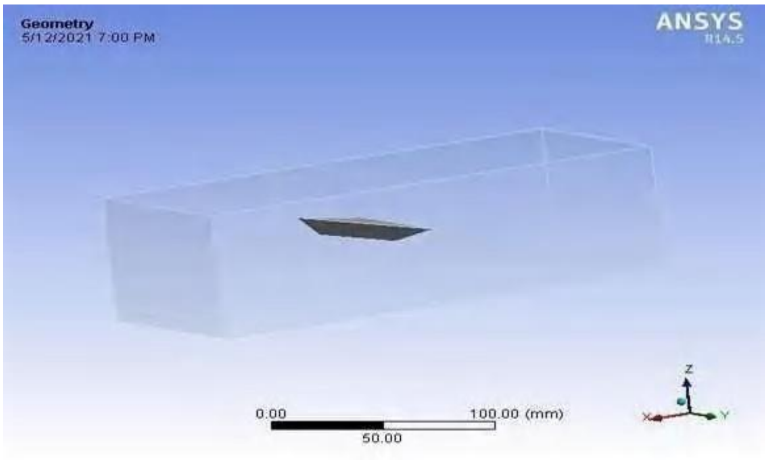

Fig:1 Geometry

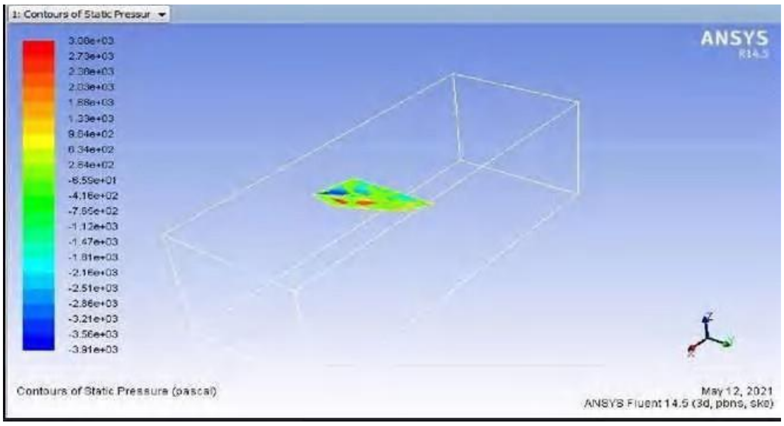

Fig: 2 Pressure at M=0.2 and 10 degree AOA

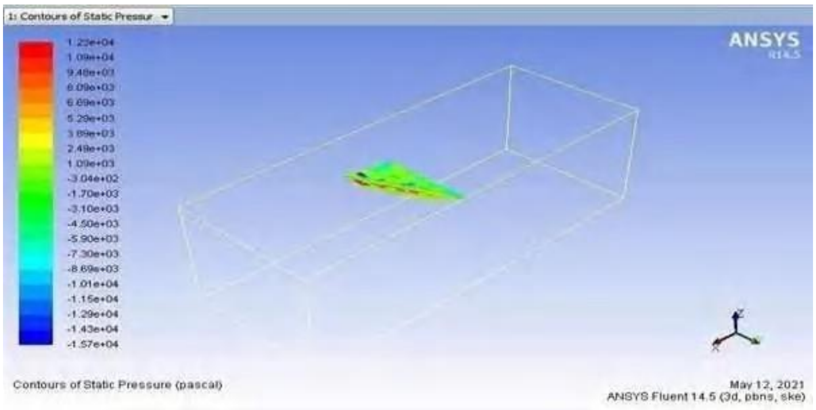

Fig: 3: Pressure at M=0.4 and 10 degree AOA

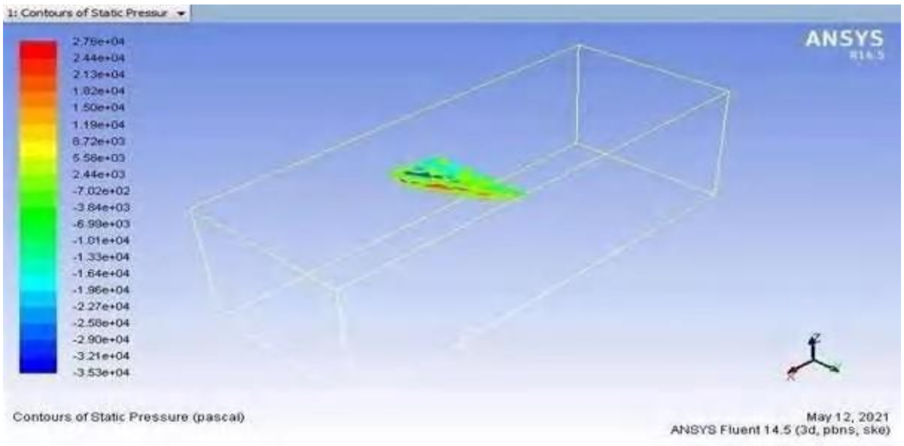

Fig: 4: Pressure at M=0.6 and 10 degree AOA

Comparison of Parameters

Inclination	Mach Numbers	Pressure	Kineticenergy	Shear stress	Mass Flow Rate	Velocity
10º	0.2	3.06E+03	3.18E+02	3.45E+01	7.5101852E-06	9.129E+001
	0.4	1.23E+04	1.26E+03	9.73E+01	1.2755394E-05	1.828E+002
	0.6	2.76E+04	2.82E+03	2.01E+02	3.5881996E-05	2.737E+002
15º	0.2	2.90E+03	3.00E+02	3.58E+01	4.025734E-06	9.040E+001
	0.4	9.27E+03	1.20E+03	9.00E+01	4.3749809E-05	1.801E+002
	0.6	2.60E+04	2.75E+03	1.89E+02	1.253752E-04	2.693E+002
20º	0.2	2.33E+03	2.90E+02	3.68E+01	2.3841858E-06	8.920E+001
	0.4	4.52E+03	1.15E+03	8.70E+01	1.1963582E-04	1.784E+002
	0.6	2.07E+04	2.65E+03	1.75E+02	1.600528E-04	2.678E+002

Table 1: Comparison of parameters with respect to Mach number and AOA

IV. CONCLUSION

In this study the half edged delta wing with sharp leading edge with 60degree sweep back is designed and the model is simulated at various required conditions and the results are obtained gradually in timed process. From the results we obtained we can observe that, for a fixed mach number the pressure over the wing is decreasing with increase in the angle of attack (10,15,20 degree angles of attack) . The mass flow rate is decreasing and the velocity of the flow over is wing is also reduced with the increase in the angle of attack and the kinetic energy of the flow is also decreasing with increase in angle of attack at a fixed mach number .As the pressure values are increased with respect to increase in mach numbers(M=0.2,0.4,0.6) at a fixed angle of attack and the pressure values are decreasing with increase in angle of attack at a fixed mach and the velocity of free stream is decreasing with fixed mach and variation in angle of attack .And the kinetic energy of flow is decreasing with increase in angle of attack at fixed mach but with the constant angle of attack and increase of mach the kinetic energy is increased. And the velocity of stream is increasing with increase in mach number at a constant angle of attack .The main decrement of pressure is on the top surface of with increase in angle of attack but there is a serious surge in the pressure at the bottom surface of wing but in the overall increment or decrement of pressure with angle of attack variation at constant mach is very small nominal value but at constant angle of attack the pressure variation is slightly high. So we conclude that for an aircraft with half edged delta wing to work at its maximum efficiency the desired conditions are high mach velocities and optimum angle of attack.

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